Wind and Solar Power for Ships

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Situation

- Cruise Shipping is the most energy consuming form of tourism per tourist basis
- Global fuel consumption of cruises in 2007 was 31.3 million tones (Mt) which corresponds to 96 Mt of CO_2.[1]
- Cruise ships emit more CO_2 than Dash 800 bombardier aircraft

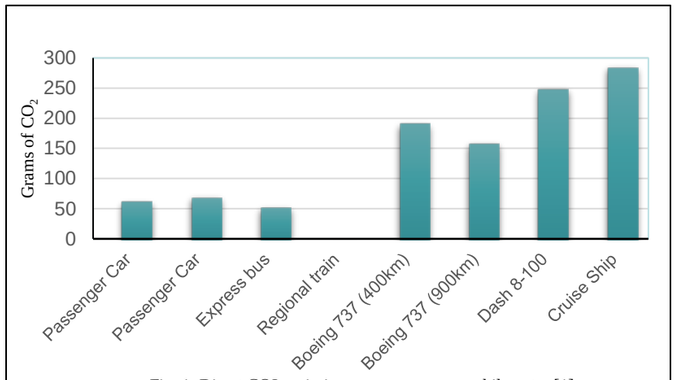

Fig. 1: Direct CO2 emissions per passenger per kilometre [1]

Problems

Wind energy:

- Power produced by conventional wind turbine is inconsistent and insufficient
- The wind turbine has to be placed such that the power produced is maximized and wind drag is minimized
- Conventional wind turbines are unstable against ocean winds
- At sea, metals corrode more easily and regular replacement maintenance is difficult

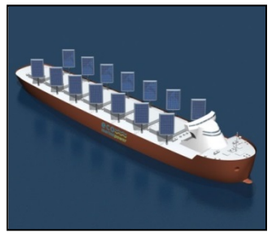

Fig. 2: Solar cells panels [2]

Solar Energy:

- Conventional solar panels take up a lot of deck space
- Installation of a practical number of solar panels is costly
- Electricity requirement, mainly from refrigeration equipment needs to be renewably supplied

Solutions

Wind Turbine:

- The installed wind turbine will be the Vertical Axis Wind Turbine (VAWT) instead of the conventional Horizontal Axis Wind Turbine (HAWT)

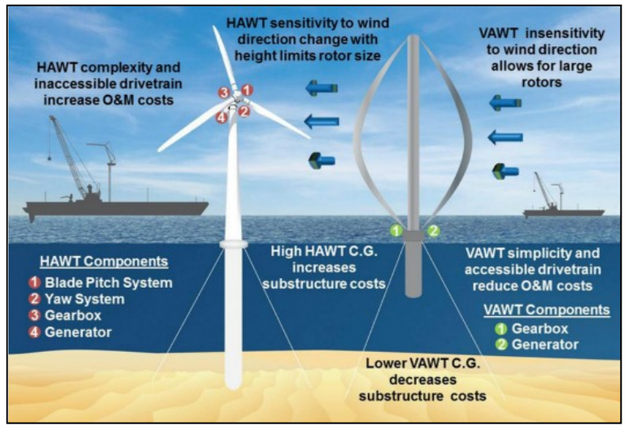

Fig. 3: Horizontal (HAWT) vs Vertical (VAWT) Axis Wind Turbine [3]

- Turbine model : UGE – 4K (4000 W)
- Made from carbon fibre and has a height of 4.6m
- Installed in the front: Reducing air resistance and drag force, thus reducing fuel consumption
- VAWT S-shape blades structure can operate in any wind direction and its blades tip speed is lower than a similar rated horizontal axis wind turbine

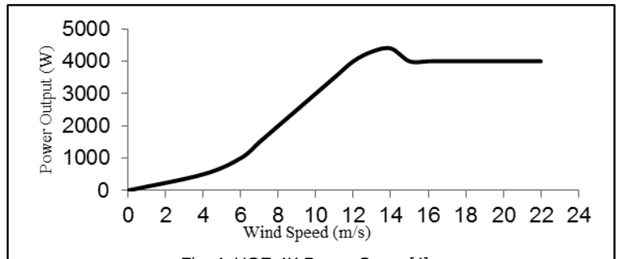

Fig. 4: UGE-4K Power Curve [4]

- Power in the wind = $0.5 \times \rho \times A \times W^3$; where ρ = Density of air (kg/m3) ; A = Area of turbine (m^2) ; W = Wind speed (m/s)
- In one year, two UGE-4K turbines produce a total of 23000 KWH = 84 tons of fuel

Solutions

Solar Panels:

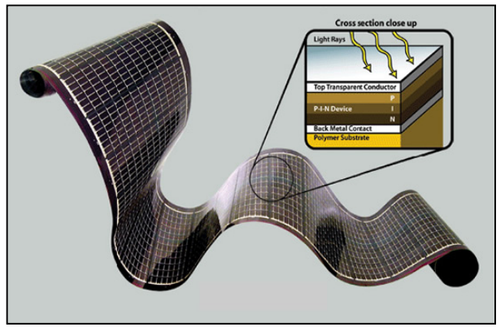

Fig. 5: Flexible Solar cell [5]

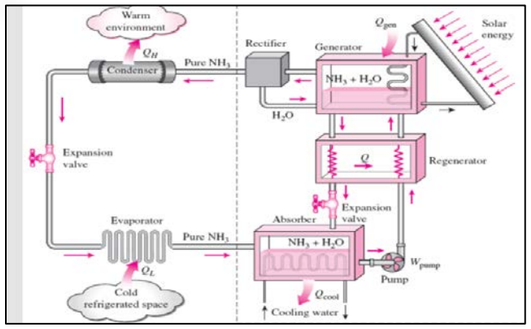

Fig. 6: Thermodynamic Cycle [6]

- Use of flexible solar panels
- Attached to the upper sides of the ship
- No of solar panels needed = 1607 panels
- These produce a total of 11.2 kW of power
- Total cost at $ 132 per unit = $ 212, 124

- Coefficient of Performance $(COP) = \frac{\text{Desired Output}}{\text{Required Input}}$
- Increased efficiency
- Application: Air conditioning, food and beverage storage

Evaluation

- 35% of fuel is conserved using VAWT, and 13% of fuel is conserved using solar cells
- The solutions offered in the project are applicable to bigger ships like cargo and naval vessels that use nuclear energy as fuel regardless of high cost, civic liability and disposal issues
- The proposed solutions might be costly but on the long run the investment will be regained as fuel price will increase as expected
- The biggest advantage is reduction in CO_2 emissions and waste fuel discharge leading to savings in air and marine pollution

References

[1] H.J. Walnum, "Energy use and CO_2 emissions from cruise ships-A discussion of methodological issues," *VESTLANDSFORSKING*, 2011. [Online]. Available: http://www.vestforsk.no/filearchive/vf-notat-2-2011-cruise.pdf. [Accessed: Nov. 13, 2013].

[2] Wind and Solar Power for Ships. “Using Renewable Energy for Greener Shipping.” Internet: http://www.ecomarinepower.com/images/stories/aquarius/aquarius_eco_ship_2b.jpg,n.d